ON THE

NUCLEUS

OF THE

ANIMAL AND VEGETABLE

"CELL."

BY

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*From the Edinburgh New Philosophical Journal for October 1847.**

"It will be remarkable if the mammiferous ovum, which, because of its minuteness and the supposed difficulty of obtaining it, had been generally considered beyond the reach of satisfactory observation, should now become the means of studying, not merely other ova, but certain processes by which nourishment is communicated, and the growth of the body effected at all future periods of life. Such, however, I think will really be the case."

This was long since written by myself,† under a conviction that the nuclei of all cells were the seat of changes of the same kind as those which I had shewn to attend the fecundation of the mammiferous ovum, in the nucleus of its germinal vesicle or cell—the germinal spot. Whether in the opinion then expressed I was mistaken, will be seen from the following pages; intended to contain not only an outline of the elaborate process producing the changes in question, but also a few examples of the extent to which I have the satisfaction to find my observations have been confirmed, and my views formally applied.

I think it peculiarly proper to offer this communication to the Wernerian Society; having been first induced to enter upon microscopic research by the perusal of a work on Em-

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* The substance of a paper read before the Wernerian Society of Edinburgh, on Saturday, the 3d April 1847, with some additions.

† Phil. Trans. 1841, p. 201.

bryology put into my hands by the revered President of this Society, Professor Jameson.

The nucleus of the vegetable cell had long been noticed before it received any particular attention, which was first given to it by our distinguished fellow-countryman, Robert Brown ; who states this body to have been so neglected, that there are instances of botanists having actually figured the nucleus in the cell, without thinking it worth noticing in the explanation of their plates. The structure in question did not obtain the attention of physiologists in general until the year 1838, when Schleiden published his observations on the nucleus of the vegetable cell; which appear to have given rise to,—for they were immediately followed by,—the extensive and invaluable researches on cells in animal tissues, by my friend Professor Schwann. And never, perhaps, did the microscope yield a richer harvest of observations than on that occasion in his able hands ; for to Schwann we are indebted for the great discovery, that the elementary parts of tissues have a like origin in cells, however different the functions of those tissues. It is with regret that I place his name in the list of those from whose observations on *cellular development* my own widely differ,—the differences relating to points of cardinal importance.

Schleiden shewed the nucleus to be the part that gives origin to the membrane of the cell, which membrane when in an incipient state he compared to a watch-glass on a watch. But Schleiden supposed that when the nucleus has given origin to the membrane of the cell it has performed its office; and that, not being further required, the nucleus then either remains inert in the cell-wall, or is "cast off as a useless member," and "absorbed." I am not aware that that opinion of Schleiden was questioned in any quarter, until my own observations had shewn it to be the very opposite of the truth. So far from the nucleus of the cell either remaining inert in the cell-wall, or being absorbed as useless, it is a most active agent, and endowed with properties of the first importance; while the membrane it forms is a structure subordinate thereto.

From its property of originating the membrane of the cell, Schleiden gave to the nucleus the name of Cytoblast or cell-germ. In the cytoblast he saw what seemed a smaller body, the nucleolus; and he, as well as Schwann, Müller, Valentin, and Henle, supposed the smaller body to exist first,—the substance of the cytoblast, or larger body, they believed to be deposited *around* the smaller one,—and the substance of the membrane of the cell to be deposited *around* the cytoblast.*

According to my observations, it is not so: I find the process to be of a widely different character; so different, indeed, that it may be termed the very opposite of that supposed by the German physiologists just mentioned. It is true that a minute pellucid, and, as will presently be seen, a very important globule (fig. 1), exists before the cytoblast. But it is not true that a finely granular substance is "deposited around" that pellucid globule, so as to make the nucleolus seen in the cytoblast identical with the previously existing pellucid globule. That previously existing pellucid globule *absorbs and assimilates* new matter, and, at the same time, enlarging and becoming finely granular, assumes the form in fig. 4, the cytoblast of Schleiden,—having prepared a nucleolus for itself. Nor is it true that the membrane of the cell is *formed around* the cytoblast. *The outer part of the cytoblast* rises in the form of membrane, so as to produce fig. 5, a cell; another portion of the cytoblast enters into the formation of the contents of the cell; and what is left of the cytoblast in the cell-wall, becomes the nucleus of the cell.

Fig. 1.

This nucleus, said to remain inert in the cell-wall, or to

* The following is the substance of a statement made by Valentin, as briefly expressing the views on this subject of Schleiden, Schwann, Müller, Henle, and himself; and as being descriptive of the first formation of the elements of tissues:—In a fluid, says he, there are precipitated granules, which are nucleoli; *around* the nucleolus there is deposited a finely granular substance, by which there is formed the nucleus (cytoblast); and *around* the nucleus there is formed the membrane of the cell. The principle of formation of the nucleus *around* the nucleolus, is essentially the same as that of the cell *around* the nucleus. Valentin concludes that this process may be described by the expression, heterogeneous *circum*-position.—*Repertorium*, 1839, ii., p. 284.

be "cast off as a useless member" and "absorbed," is the seat of a most elaborate process, which I will now endeavour to describe: first remarking, that the woodcuts are intended for the purpose of assisting in the description of that process, rather than as minutely representing nature. Drawings in which the latter has been attempted, taken from hundreds in my memoirs, are given in the plates; and these will be rendered more intelligible by the woodcuts. (In many of the drawings, for instance in those of fig. 39, Plate I., the structure is so minute that it should be viewed with a pocket lens.)

The "cytoblast" of Schleiden has usually a discoid or amygdaloidal form, and in substance appears finely granular* (fig. 4); and his "nucleolus," the pellucid point in fig. 4, I find to represent the situation of a brilliantly pellucid substance, which, from its appearance, I have called *hyaline*.†

Fig. 2.

Fig. 2. Two portions of hyaline enlarged, and surrounded by globules of extreme minuteness, which seem to have their origin in the bodies they surround. One of these bodies presents a faint circular marking at the side, *not yet formed in the other*. This circular marking is the incipient nucleolus. Compare with α and β, the two states of nuclei, in Fig. 33, Plate I.; a nucleolus being there present in β, and not yet formed in α.

Fig. 3.

Fig. 3. That which was a large portion of hyaline in fig. 2, is now an incipient cytoblast, and already membranous at the surface; the minute globules, now no longer seen, having apparently entered into the formation of its membrane. Compare with many figures in Plate I.

Fig. 4.

Fig. 4. The cytoblast of Schleiden; differing from the body fig. 3, in being finely granular, except in the region of the circular marking or nucleolus, which first made its appearance in one of the portions of hyaline fig. 2. Compare with figs. 35, 36, &c., Plate I.

* In animals this finely granular substance is, or corresponds to, the red colouring matter of the corpuscles of the blood. See figs. 35, 36, &c., in Plate I.

† A term suggested to me by Professor Owen.

Fig. 5. The cytoblast has become a cell; its contents finely granular,—the remains as they are of the finely granular substance of the cytoblast in the preceding figure.* *That which was the nucleolus in figs.* 2, 3, 4, *is now the nucleus.* This nucleus, a mass of hyaline, is surrounded by minute globules, as in fig. 2; and, like one of the bodies in that figure, *presents, in its turn, an ill-defined nucleolus.* Compare with two of the cells β, in fig. 34 of Plate I.

Fig. 5.

Fig. 6. The minute globules are no longer seen. They appear to have entered into the formation of the membrane by which the hyaline nucleus is now surrounded. This hyaline nucleus is in the same state as the entire body fig. 3,—*that of a young cytoblast.* It represents the "hollow nucleus" and "inner cell" of authors. *The nucleolus is now well-defined.* Compare with γ of fig. 34, in Plate I; and *read the description of that figure.*

Fig 6.

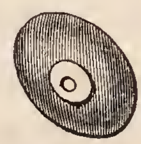

Fig 7. The hyaline nucleus of the cell has become finely granular, *and is now as much a cytoblast as the body, fig.* 4. Compare with the nucleus of several cells in fig. 39 of Plate I., and with the concentric cytoblasts in fig. 41 of the same Plate.

Fig. 7.

Fig. 8. The nucleus or cytoblast of fig. 7 has become a cell, and *that which was the nucleolus in fig.* 7, *is now the nucleus of this cell.* Farther, in the centre of the nucleus which had been a nucleolus, *another nucleolus is coming into view.* The hyaline, much increased in quantity, is giving off globules into the surrounding substance, and is hence nodular or star-like in its form. Compare with two cells on the right hand, and with other bodies in fig. 39 of Plate I.

Fig. 8.

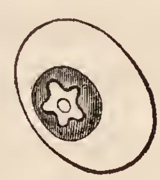

Fig. 9. The segments of the nodular or star-like hyaline

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* The first contents of all cells have a like mode of origin; and it is not easy to say where the cytoblast terminates, and the cell begins; so that often one is obliged to use almost indiscriminately the terms "cytoblast" and "cell."

have assumed independent forms; having appropriated the finely granular substance into which they were cast, and thus become young cytoblasts. What was left of the central hyaline has increased in quantity, and, as in figs. 2 and 5, has become surrounded with minute globules. Compare with blood-corpuscles above the middle part of fig. 39, in Plate I.

Fig. 9.

Fig. 10. The young cytoblasts are larger. The minute globules are no longer seen, having probably entered into the formation of the membrane by which the central hyaline is now surrounded. This central hyaline is in the same state as the nucleus of the cell in fig. 6. It is a young cytoblast. Compare with several cells in fig. 39, of Plate I.

Fig. 10.

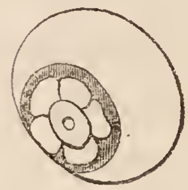
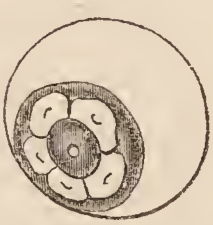


Fig. 11. What were young cytoblasts around the central hyaline, are now young cells; which surround what is now a true cytoblast; for the central hyaline, pellucid in fig. 10, is now finely granular. Compare with β in fig. 37, and with several cells in fig. 39 of Plate I.

Fig. 11.



Figs. 12, 13, 14, 15. To describe the central portion of the nucleus in these figures separately, would be to repeat the description just given of the entire nucleus in figs. 8, 9, 10, 11; for the appearances are the same, and referable to a continuation of the same process.

Fig. 12.

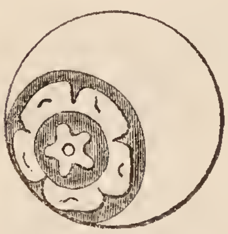


Fig. 13.

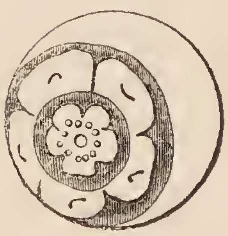


Fig. 14.

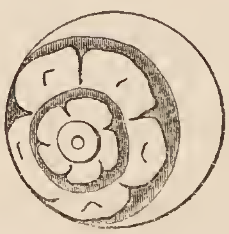
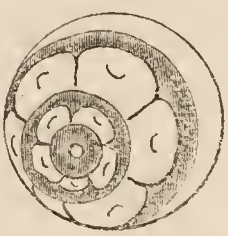


Fig. 15.



The only remarks to make concerning figs. 12 to 15, are these, viz., that the layer of young cells already formed in fig. 11, becomes pushed farther and farther into the interior of the cell by the succeeding brood; and that as each nucleus

is transformed into a layer or brood of cells, its place is taken by the enlarging nucleolus; which again is succeeded by a fresh nucleolus, arising in the centre from which the former had enlarged. Compare with a cell in the woodcut fig. 26, and with a corresponding cell in fig. 39 of Plate I.

And this process, it will be seen, begins before the complete formation of even Schleiden's cytoblast. See figs. 2, 3.

The membrane of the nucleus or cytoblast, becoming the inner cell in fig. 8, and represented in all the succeeding figures,—though distinct enough, capacious, and for some important purpose *filled with pellucid fluid when in a central situation*, (Plate I., fig. 45 β),—is rarely seen with distinctness when subsequently pushed out from the centre by a fresh brood, and made to separate two layers of cells: and often it entirely disappears, as shewn by several bodies in fig. 39, Plate I.

I have just spoken of the cell-membrane, as formed by minute globules. An immeasurably minute cell-formation, however, seems even here to intervene. Fig. 38 in the Plate presents part of the membrane of a very important cell produced by the coalescence of minuter cells, the formation of which it is not difficult to follow.* And you afterwards find in its substance the nuclei, or germinal centres, of the cells which formed it (see the figure). Yet so very small is that cell at first, that two hundred millions of them could be contained in a cubic inch. To that cell (my *ovisac*†) I shall presently return. I wish now to add, that there is thus a considerable difference between my views and those of the German physiologists just mentioned, as to the mode of origin not only of the cytoblast, but of the membrane of the cell. The substance of the larger body is not deposited *around* the the smaller, but the smaller is transformed into the larger. The nucleolus *becomes* a cytoblast, and the cytoblast *becomes* a nucleated cell.

From the foregoing remarks and figures it will also be

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* See in Phil. Trans., 1841, Plate xxv., figs. 170, 171, 172, 173.

† Phil. Trans., 1838.

seen, and it is important to observe :—1. That in the early stages of its formation the cytoblast of Schleiden has no nucleolus, but acquires a nucleolus before its formation is complete. 2. That when the cytoblast has formed a cell, the nucleus of this cell is what had been the nucleolus of the cytoblast; and, 3. That now another nucleolus comes into view in the situation which had been occupied by its predecessor. 4. That this process continuing the same, the nucleus of one stage is the nucleolus of an earlier stage; there being a continual succession of nucleoli in the centre. 5. That it is a process which begins before the complete formation of even Schleiden's cytoblast; in fact begins with the existence of the minute pellucid globule, which thus becomes transformed into that cytoblast. 6. That this process is the very opposite of that described by Valentin in his statement of the united views of Schleiden, Schwann, Müller, Henle, and himself, as forming the elements of tissues.

Figs. 1 to 15 represent the process in no more than the primary or main centre of each cytoblast and cell; they would have been complicated by any attempt to exhibit it in the secondary centres; where, however, abundant evidence is afforded that the process is the same, for the secondary cells fill with other broods in like concentric order, and leave no doubt whatever that every segment of the nodular or star-like hyaline in fig. 8, after having become a globule, passes through in succession the conditions represented in figs. 2, 3, and 4, before it becomes a cell. (And hence it seems to be, that the process is obscured by immeasurably minute and highly refracting globules).

Wishing to confine the foregoing remarks as much as possible to the mode and order of formation of the cytoblast, the cell, the nucleus, and the nucleolus,—I have hitherto said nothing in this paper of an orifice often seen by me to connect the nucleolus with the exterior of the cytoblast and cell; and adding much to the refraction of light which takes place at that point. This orifice, which I first saw in the germinal spot in 1840, will be found represented in many figures, and

constantly referred to in my later memoirs; and I shall presently mention an observation made last year by Dr Harless while at Triest, which affords a highly interesting proof of its existence. I need not add one word to shew the importance of an orifice in such a situation.

The ovum and its ovisac arise out of a cytoblast, Plate I., fig. 37. I must refer to my memoirs for the details of this change,* intending here to confine my remarks to the mature ovum.

The essential part of the ovum is the germinal vesicle or cell (the part not coloured in the figure last referred to, and *c* in fig. 45); and more particularly its nucleus,—the *germinal spot.* The first changes connected with fecundation, that are discernible in this spot in the ovum of the Rabbit, seem to be of a preparatory nature; for they begin *ante coïtum*, the animal being in the state of heat. They are such as those described in pp. 205–208, and represented in figs. 7 to 15. The germinal vesicle thus fills with cells in concentric order (fig. 45, *c*); and now the outer layer, liquefying, becomes a sort of pabulum for the second layer, which then occupies its place, and so on.

At length the ovum becomes fecundated, by the introduction of a substance from the seminal fluid into the hyaline centre of the germinal spot, which then passes to the centre of its vesicle or cell (fig. 16).† And now the contents of the cell, no longer in communication with the exterior by a parietal nucleus, undergo changes, having sole, or at least especial reference to that fecundated centre. The concentric layers of cells are successively and rapidly dissolved, and as speedily replaced by fresh broods of cells arising in the centre. It must be recollected too, that the cells in the concentric layers are themselves filled with other cells, undergoing like changes.

Fig. 16.

* Phil. Trans., 1838, Plate V., figs. 1, 2, 3, 18, 19, 20, and Phil. Trans., 1841, Plate XXV., figs. 164 to 173.

† This figure, and several which follow it, are in outline only.

After this assimilative process has continued for a sufficient length of time, that which has become the nucleus divides into two halves (fig. 17); which two halves, by appropriating the result of this cell-formation, and by the same process as that above described, are enabled (fig. 18) to give origin to two cells, intended to succeed the parent. (For each of the two halves just mentioned is a globule of hyaline, such as the largest of those in the woodcut fig. 1; gradually becoming (figs. 2, 3) a cytoblast (fig. 4), and then a cell (fig. 5); and the nucleus of this cell presents a repetition of the same process as that bringing successively into view, figs. 6 to 15; which should be rapidly glanced over in their numerical order, the eye being directed to the ever active central hyaline.)*

Fig. 17.

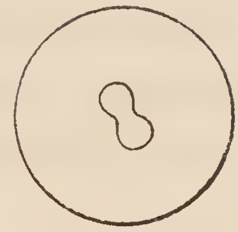
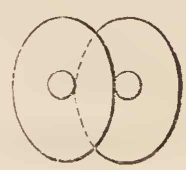


Fig. 18.

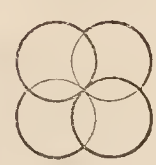
The mysterious hyaline centre of a nucleus, that is to say, the centre of the germinal spot, exercising an attractive force, is thus the point of fecundation in the ovum; and assimilation having been effected, and division of the nucleus accomplished, and the membrane of the germinal vesicle, as well as all the transitory cells, having disappeared by liquefaction, two cells remain (fig. 19), the foundation of the new being.

Fig. 19.



Of the further changes induced by fecundation, the following is an outline. After cleavage, the nucleus of each twin cell (fig. 19), gives origin to two other cells (the membranes of the parent-cells undergoing liquefaction), so that the foundation of the new being now consists of four cells, fig. 20. After cleavage of the nuclei of these four, there arise, in like manner, eight (fig. 21); and a continuation

Fig. 20.



* During these changes, the germinal vesicle enlarges at the expense of the so-called yelk, until it comes to occupy almost the entire ovum.

Fig. 21.

of the same process effects a doubling in the number of the cells, until a mulberry-like body has arisen, consisting entirely of cells ; in the centre of which mulberry is found a cell having the same general appearance as the rest, but of larger size,—a sort of queen bee in the hive. *The nucleus of this larger cell is the rudimental embryo.* And in the development of this nucleus into the embryo, the first discernible changes are of the same kind as those exhibited by the nucleus of every cell subsequently developed from it, and entering into the formation of the embryo.

From what I have already stated, it will be seen that the twin cells in fig. 19 are endowed with qualities resulting from the fecundation of the germinal vesicle, their parent-cell ; such endowment of the young cells being referable to self-division, effected by a process of assimilation.

The reproduction of the cell is thus essentially fissiparous, its contents undergoing division after having been assimilated to the nucleus ; which nucleus, therefore, it is that is reproduced,—this nucleus being a portion of the remarkable substance, hyaline, the reproduction of, or assimilation by, which seems to be a main purpose for which cells are formed.

Briefly recapitulating,—the hyaline, by a very elaborate process, assimilates new matter, and is reproduced by division. Through successive divisions of this substance, properties descend from cell to cell,—new properties being continually acquired as new influences are applied ; but the original constitution of the hyaline not being lost. (And why do nuclei continue for a while at the surface of their cells, but for a purpose analogous to that for which the germinal spot or nucleus continues, up to a certain period, at the surface of its cell in the ovum ?)

I conceive that what is seen taking place *in the manner here referred to*,—first in the germinal vesicle, and then in the individual cells, the descendants of this vesicle,—is essential to what we observe in the reproduction of the entire organism, namely, a mysterious reappearance of the qualities of both parents in the offspring ; manifesting itself, as this

reappearance does, in the assemblage and metamorphoses of the cells.

It having been in the germinal spot of the ovum, the most important of all nuclei, that I first saw the remarkable process above described, and illustrated in figs. 8 to 15, I may hereafter refer to the changes the nucleus undergoes, by the expression, *germinal spot process*. But after that process had been seen, and for a long period minutely traced, it was impossible to prosecute researches on the ovum, without discerning more or less of it in the nuclei of various cells. I recognised it in every nucleus seen to descend from the germinal spot, and subsequently saw it in bodies which, not only in the embryo, but at all periods of life, have apparently descended from that spot—the corpuscles of the blood; giving, in proof of this, hundreds of drawings in my memoirs. And having seen it also in pus and mucus globules, and epithelium cells, as well as in the elements of all the tissues examined, including those of nearly every tissue in the body, I concluded the process in question to be universal; and have never since met with a cell, the interior of which led me, for a moment, to doubt the correctness of that conclusion.

Figs. 22, 23, 24, 25, representing blood-cells of the Sparrow and fœtal Ox, afford examples of the *result* also of the process in question being the same as in the ovum; the cell in fig. 25 being about to produce twin-cells. The process, however, may lead to a very different result. Thus, in Plate I., fig. 36, β, there are seen escaping, from a parent-cell, *many cytoblasts*.*

Fig. 22.

Fig. 24.

Fig. 23.

Fig. 25.

* The cytoblasts at β in this figure are blood-discs of the fœtal Sheep. It will be seen that they are not round, like the blood-discs usually circulating in the Mammalia, but elliptical. The fact is that they are *young* blood-discs, having the same form as that which, according to my observations, is the first form of blood-discs in all animals. I saw it to be so at least in animals at both ends of the scale, including Man. I have given drawings of these blood-discs from the Tadpole, fig. 35, and Leech, fig. 36 α. There is a form, however, anterior

Descending, as cells thus do, from an original mother-cell, and this by cleavage of the nucleus of that mother-cell, and all subsequent nuclei being propagated in the same way, by fissiparous generation,—such being the process, every nucleus or particle of hyaline is a sort of *centre*, inheriting more or less of the properties of the original nucleus, the germinal spot of the fecundated ovum; and exercising an assimilative power. (The corpuscles of the blood are floating centres of assimilation.)

I wish it to be distinctly understood, that, in my researches, I always endeavoured to keep strictly to observation, avoiding all theory; and it may be here remarked, that some of those on the divisions in the ovum, just referred to, were made before I knew much of cells. Of one kind of animal alone, the Rabbit, about 150 were sacrificed in these observations; some of the most important of which I had the opportunity of enabling my honoured friend Professor Owen to confirm, by submitting the objects under the microscope to his practised and most rigorously scrutinizing eye.

How satisfactory now to find my observations confirmed by researches subsequently made by others. Thus the younger of the brothers Goodsir has since found, in the ovum of a cystic entozoon,* the germinal vesicle to fill with cells from the germinal spot, by a process obviously the same as that which I had described in the ovum of the Mammal; the germinal vesicle enlarging so as to occupy the entire ovum. Compare in Plate I., figs. 45 and 46; and read the description of the latter figure.

Farther, how satisfactory now to find those observations of mine adopted and formally applied in various departments

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to that of the elliptical disc, and, of course, quite as general; viz., the globular, for every disc (cytoblast) appears to have once been a pellucid globule of hyaline.—No observer can learn the structure of the blood-corpuscles, who does not carefully investigate their mode of origin; and this, not in blood taken from large vessels, which are merely channels for conveying it, but in that contained, and almost at rest, in the capillaries, and especially in the capillary plexuses and dilatations.

* *Cœnurus cerebralis.* Trans. Royal Society, Edinburgh. 1844. Vol. xv., Pl. xvi.

of physiology; for instance, by Professor Goodsir, who thereby makes a plain pathway through some of its most hidden regions.* Thus for example it is that, regarding every nucleus in his germinal membrane (Bowman's basement membrane) as a germinal spot,—and keeping in view what he denominates "that most important observation of Martin Barry on the function of the nucleus in cellular development,"—he is enabled to shew, that epithelium cells have their origin in the *nuclei* of that membrane,—an acknowledgment to me the more valuable, from the fact, discovered by Goodsir, in the ducts of glands, that the epithelium cell is the secreting organ.

This brings me to notice a chapter by the same author, entitled "*Centres of Nutrition*," regarding which he writes as follows:—"The phenomena presented by these centres incline me to regard them as destined to draw from the capillary vessels, or from other sources, the materials of nutrition, and to distribute them by development to each organ or texture after its kind. In this way, they are to be considered centres of germination; and I have elsewhere named them germinal spots, adopting the latter term from the embryologists. The centre of nutrition with which we are most familiar, is that from which the whole organism derives its origin—the germinal spot of the ovum. From this all the other centres are derived, either mediately or immediately; and in directions, numbers, and arrangements, which induce the configuration and structure of the being."†

That I can have no hesitation in admitting all the attractive force here attributed by Professor Goodsir to those centres, is obvious from its having been myself, I suppose, who made known the fact, that "the whole organism derives its origin from the germinal spot of the ovum;" and from what I wrote six years ago on the subject of centres in general. Thus, in the Philosophical Transactions for 1841, p. 201, will be found the following words, already quoted,—resulting, it will be seen, from my conviction that the germinal spot process, described by myself, was the same in all

* Anatomical and Pathological Observations by John Goodsir, F.R.S.E., &c. and H. D. S. Goodsir, M.W.S. 1845.

† Loc. cit., p. 1.

cells. I said, "It will be remarkable if the mammiferous ovum, which, because of its minuteness and the difficulty of obtaining it, had been considered beyond the reach of satisfactory observation, should now become the means of studying, not merely other ova, but certain processes by which nourishment is communicated, and the growth of the body effected at all future periods of life. Such, however, I think will really be the case."

As affording probability that this anticipation would be realized, I figured *centres*, *special centres*, of reproduction and assimilation; directing attention more particularly to such centres as were situated in the walls of tubes,—as, for instance, in those entering into the formation of muscle (fig. 26), the crystalline lens (fig. 27), and nerve: on which I remarked, "We may hereafter see reason for thinking it not unimportant that the contents of the 'primitive' cell and those of the 'secondary' cylinder should have their origin in the nucleus."* And subsequently, when those centres were referred to, my views regarding them were stated in the following words:—"I conceive them to be *centres* of assimilation; having been led to this opinion by observing, in the first place, that they present the remarkable orifice in question; and, secondly, that they are reproduced by self-division. They descend in this manner from the nuclei of the original cells of development, *i.e.* from the nuclei of the corpuscles of the blood. That they are the source of new substance is very obvious; for they may be seen either unwinding into a filament, or becoming spindle-shaped to form one. But what I wish to

Fig. 26.

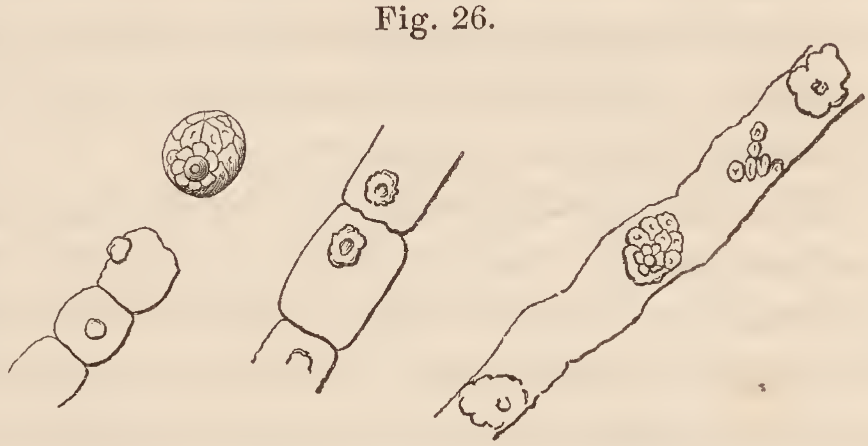


Fig. 27.

* Phil. Trans., 1841, p. 236.

add is, that the origin of new filaments in these nuclei appears to me to have especial reference to that assimilation of which they seem to be the centres. Although every nucleus seems to possess a reproductive property, there are thus special centres of reproduction. Such centres were also particularly indicated in one of my former memoirs,* as existing in the epithelium, the pigmentum nigrum, 'cellular' tissue, and cartilage. In describing the first origin of muscle, nerve, and the crystalline lens, also, I directed attention to such centres, stating that we might hereafter see reason for thinking it not unimportant that the contents of the 'primitive' cell, and those of the 'secondary' cylinder, should have their origin in the nucleus; and I was particularly desirous of connecting this fact with the existence of the orifice in question. It will now be seen that I had in view the subject of *assimilation* now referred to."†

Such, then, having been my views long since, I can have no hesitation in admitting all the attractive force attributed to those centres by Professor Goodsir; whose theory of nutrition, indeed, harmonizes so fully therewith, that a friend pointed it out to me as the formal application of my views. And on a perusal of the important volume just referred to, by the brothers Goodsir, I have the satisfaction to find, that all in it relating to the "function of the nucleus in cellular development," appears to be derived from the same source.

I have here great pleasure in acknowledging that Professor Goodsir's discovery of the real structure of basement membrane, appears to me an important step towards a solution of the question—How do the corpuscles of the blood enter into the formation of structures arising on the "free surfaces of parts or organs"? That the blood-corpuscles *do* enter into the formation of such structures, I must take to myself the credit of having shewn, by tracing them into the incipient chorion in the Fallopian tube.‡ But it is now possible, I think, to offer an explanation of the mode in which they are

* Phil. Trans., 1841, par. 119, 120, 135, 144.

† Edinburgh New Philosophical Journal, October 1, 1843, pp. 207, 208.

‡ On *the Corpuscles of the Blood*, Phil. Trans. 1840.

made to do so; which will be found at the end of this paper. I would here merely add that the discovery now referred to, is that of *nuclei* found by Goodsir in the basement membrane, the presence of which nuclei induced him to call that membrane a *germinal* membrane; for, adopting my views on the "function of the nucleus," he believes the nuclei in his germinal membrane to absorb from the capillaries on one side of that membrane, and give origin to the epithelium-cells on the other.

Here I must not omit to say, the orifice I have so generally met with in the nucleus, is most important in the function of absorption by that body, especially in centres such as those present in germinal membranes, fig. 50, and in the tubes, figs. 26 and 27; that orifice being in cells, as well as in certain of the Infusoria, a sort of mouth for nutrition; and in all it is equally an opening for fecundation, or what is equivalent to fecundation, for the introduction of a substance to be subjected to that assimilative process which prepares the cell for either reproduction or any other purpose. In tissue-tubes, such as those in figs. 26 and 27, the nucleus with its orifice seems to remain for the purpose of exercising an appropriative power,—forming muscle in one instance, fibres of the lens in another, and so on.

Of the existence of the orifice in question, we have, I think, a highly interesting proof in observations made last year by Dr Harless;* who, in examining cells of the ganglion-globules in the lobus electricus of the Torpedo Galvanii, found nervous filaments connected with what he terms the nucleus of an inner cell. I have copied three of his figures; and if these be referred to, Plate I, fig. 44, it will be found that his nucleus of the inner cell is my orifice, situated in α and β in a hyaline nucleus, membranous at the surface,† and in γ in a finely granular nucleus or cytoblast,—being in the latter double. The nervous filaments so connected, and, as Dr Harless says, *proceeding from* the point in question, he describes as pellucid, and as belonging to the medulla of the primitive fibres. In some instances, he saw two such filaments connected with

* Müller's Archiv, 1846, No. III., p. 283.

† The "hollow nucleus" of Schwann.

cells in this manner (see β in fig. 44),—the directions taken by the two filaments having been so different, that he suggests whether one of them may not have belonged to a cerebral fibre, and the other to a peripheral nerve.

From all that I have written concerning the nucleus of the cell,—which had been supposed to remain inert in the cell-wall, or to be "cast off as useless and absorbed,"—and especially from what I have said regarding the mysterious centre of that nucleus—the primogenital, absorbing, assimilating, formative, dividing, subdividing, even vibratory, and ever active hyaline—it will be seen that to me Dr Harless's observation must be one of surpassing interest. I refrain, however, from further remarking on it; the subject having been here referred to merely for the purpose of shewing that, by the existence of a connection between the nucleolus of the cell and nerve, that of the orifice in question is implied.

In connection with Professor Goodsir's observations on the placenta, I refer to my own, previously published, on the mode of origin of the chorion (Plate II., fig. 54 $\varkappa$); for the purpose of pointing out in the nuclei of the cells which enter into the formation of the chorion, the source of the germinal spots or centres figured by Goodsir in advanced stages of that membrane. (I would also direct attention particularly to a fact above referred to, the presence of nuclei or germinal centres in cell-membranes however small at first,—as for instance in the membrane of the ovisac. This I think not undeserving of remembrance, in connection with the subject of the enlargement which some cells undergo in both healthy and morbid growths.)

In his important paper on secretion, published in 1842,* Professor Goodsir recognises cells in general as endowed with a property which, I must do myself the justice to say, had not been overlooked by me when examining such cells as came under my notice. Thus, the year before, I had shewn the pigmentum nigrum to have its origin in cells. But it is evident Professor Goodsir was not aware of what I had

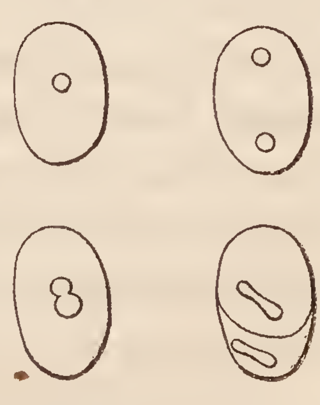
* Trans. R. S. E., 1842.

written, or he would not have supposed the secretion contained in the cell-cavity to be produced by the cell-*wall;* for in a subsequent paper, in which he attributes the property of secretion to the *nucleus* of the cell, he acknowledges it to have been my observations "*on the function of the nucleus in cellular development*" that convinced him he had been in error in attributing that property to the cell-*wall.* So minutely had the mode of origin of the red colouring matter and that of the pigmentum nigrum been investigated by me, that I had found, in the first place, the red colouring matter to be formed by the hyaline nucleus of the cell; and, secondly, that red colouring matter to afford a medium for the formation of the black pigment, which also was seen to arise out of the hyaline nucleus within the cavity of the cell.

As all the tissues have their origin in corpuscles presenting the same colour, form, and size, as corpuscles of the blood,—and if all cells are derived, as I believe them to be, from the corpuscles of the blood,—it will be seen that the red colouring matter is a secretion of importance, and this on two accounts. In the first place, it is universal,—for everywhere, in greater or less quantity, it is reproduced; and secondly, it no doubt affords a medium for the formation of other substances in the cell-cavity, as well as for that of the pigmentum nigrum. *It corresponds in fact to the finely granular substance of every nucleus and cytoblast, which comes into view as new matter is appropriated by the hyaline.*

I observe confirmations in other quarters also. Some of these were referred to on former occasions,* and need not be particularly mentioned here. They are, Schwann's delineations of the cells of cartilage, figures by Valentin of ganglion-globules, and drawings by Müller of the cells of morbid growths. Figs. 28, 29, 30, and 31, since published by Dr Bagge,† represent stages of the ovum of an intestinal worm; con-

Figs. 28, 29, 30, 31.



* Phil. Trans., 1840, p. 552, note. 1841, pp. 207, 208.

† De Evolutione Strongyli, &c. 4to. 1841.

cerning which Professor Owen in a lecture remarked, " There is a close and interesting analogy between the above phenomena, which were published in 1841, and some of those communicated by Dr M. Barry to the Royal Society, in January 1841, and published in the Philosophical Transactions of the same year. The clear central nucleus of the blood-corpuscle [see figs. 22, 23, 24, 25] is there shewn to form two discs, which give origin to two cells. We may, likewise, discern in the pellucid nucleus of the yolk, dividing and giving origin to two yolk-cells, according to the German author, the hyaline nucleus of Dr M. Barry."*

Between the appearances presented by the mammiferous germ during the passage of the ovum through the oviduct and certain infusoria, including the *volvox globator* as figured by Ehrenberg (some of whose observations have been confirmed and extended by myself†), the resemblance, first mentioned by Professor Owen, is so remarkable that we cannot avoid the belief, that the same process operates in both. And farther, we have here a most interesting confirmation of the view, that the germ of the highest animals at certain periods, represents, or passes through forms permanent in the lowest.

Cilia-bearing cylinders arise, not by coalescence—as supposed by Valentin—but by division, like some of the Vorticellæ ; which they resemble also in the position of the cilia.

I have already said that in Mammals, the rudimental embryo is no other than the nucleus of a cell ; which nucleus originally has the same appearance and undergoes the same kind of changes as the nucleus of every cell subsequently developed from it, and entering into the formation of the embryo.—The first portion of the embryo that is formed is the *chorda dorsalis*, corresponding to the supposed " primitive trace" of authors. I have published a memoir‡ shewing this

* Hunterian Lectures. 1843. P. 78.

† See the Number of this Journal for October 1843, pp. 214–219.

‡ Philosophical Transactions. 1841.

to be the case; and here also Professor Goodsir informs me that he adopts my views.

It may be added, that at a recent meeting of this Society the same talented observer mentioned an observation of his own on some of the poligastric Infusoria, as fully confirming mine,—that the nucleus sometimes passes directly into a spiral form while still within its cell. And in the same quarter my observation has been confirmed,—that the spiral is the most primitive of forms. (To this, I have no doubt, is referable the spiral form retained through life by some of the lower animals:—for instance, the spiral-shelled Mollusca.)

Fig. 32.

In the blood of animals which had been kept for periods varying from 18 hours to two days after death, I found the nuclei of the corpuscles dividing into segments (fig. 32),* and the segments sending out processes; which processes, becoming acuminated, passed into cilia. The vibrations of these cilia gave to the now star-like corpuscles a locomotive power. This I have observed to be precisely the mode of origin of the mammiferous Spermatozoa,—each of which is represented by one of the segments in that figure. (The segments and the cilia, it will be seen, are processes from the hyaline. Compare with fig. 8.)

I believe that when animal and vegetable substances are macerated in water, particles of hyaline (fig. 1), which are the true cell-germs, may assume an independent life in the form of Infusoria; and thus go far to explain the so-called spontaneous generation.†

It may be added, as an observation I have not published before, that the markings on the egg-shells of Birds afford a beautiful display of colouring matter, obviously formed in cells, and there seen on a scale so large as to be visible without a magnifying power; the colouring matter being sometimes of deepest hue in what had been the situation of the nucleus,

* Phil Trans., 1841, Plate XXII., Fig. 105, γ.

† On this subject see my views more at length, in No. lxx. of this Journal (October 1843), pp. 219, 220.

and presenting zones, which grow paler and paler as they extend over a larger surface. These markings on the shells of eggs often present a curious resemblance to the ramifications of the pigmentum nigrum, proceeding from reproductive *centres;* as in eggs of several of the Buntings.

Fig. 52 in Plate II. represents part of an ovum of the Common Leech. I would direct attention to the resemblance between it and what I believe to be corresponding parts in ova of the Rabbit, figured by myself in the Phil. Trans. for 1839, Plates VI. and VII., fig. 114, &c., *bb*, *bb'*, and *a.p.*

The long pellucid area *a m* in fig. 52 is the situation of the future nervous ganglia in the Leech. Compare it with an obviously corresponding area in my figures just referred to—the situation of the future spinal cord. Again, the round iris-like body at *a*, fig. 52,—so far in advance of the other parts in its formation,—is the sucking apparatus of the Leech, endowed apparently at this early period with suctorial power. Compare it with the nucleus of my queen bee cell in the same and preceding figures; which nucleus I have always maintained to be the rudimental embryo in the mammiferous ovum.

But the figure from the ovum of the Leech was published by Professor E. H. Weber in Meckel's Archiv, in 1828,—many years before any thing was known of the physiology of cells. It serves as an example of the importance of fidelity in delineation; for I do not think that now, with all our knowledge regarding cells, we could give a drawing much more satisfactorily representing them;—at least on the same scale.

That ovum of the Leech, elliptical in form, had a length not exceeding three Paris lines. Yet even at this early period, Professor Weber noticed that the sucking property of the iris-like body, *a*, had begun to manifest itself in alternate contraction and dilatation of the central orifice; the effect of which seemed also visible in the surrounding albumen. Compare these facts with observations recorded by myself on the nucleus, *bb*, in the mammiferous ovum; remembering my orifice in the nucleus of the cell,—and all that I have now

said, as well as that which is implied by what I had previously written, on an attractive force or suctorial power as exercised by that nucleus; for assuredly no other than what had been such a nucleus is to be recognised in Weber's figure.

Professor Goodsir finds his "germinal membrane," met with on the free surfaces of parts or organs, to consist of "cells, with their cavities flattened, so that their walls form the membrane by cohering at their edges."*

I am happy to have it in my power to confirm this observation, by stating that the description now quoted fully applies to two membranes in the mammiferous ovum seen by myself, and figured in the Philosophical Transactions for 1839.† One of these, my "amnion," corresponds to what had long been called the "germinal membrane" in the ovum of the Bird: and the other I stated to be the foundation of the lamina subsequently vascular. Several figures of the latter I have copied on this occasion,—Plate I., figs. 33, 34; and I recommend an attentive perusal of the description of these figures. Tubes such as those entering into the formation of muscle, fig. 26, and the lens, fig. 27, are certainly germinal membranes; appearing thus to have the power of absorbing for nutrition. And if fig. 38 in Plate I. be referred to, it will be found that the membrane of my ovisac presents a structure of the same kind; which is interesting, 1. from the subsequent ramification of numerous capillaries on it, by which there is formed a Graafian vesicle,‡ and, 2. from its inner surface being the situation of the "membrana granulosa," a sort of epithelium. I long since shewed the incipient chorion to have a like structure (Plate II., fig. 54, *x*); and, as already said, there is good reason for believing it to be the structure of other membranes.§

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* Loc. cit., p. 3,

† Plates VII. and VIII.

‡ Of which the ovisac is now the inner membrane. Phil. Trans., 1838, p. 311.

§ While these pages are passing through the press, I learn that Professor Harting of Utrecht, and M. Mulder, have lately found the primitive membrane of the vegetable cell, even when young and before its thickening, to present *many pores*. This seems to be in perfect keeping with what I long since shewed to be the mode of origin and structure of the membrane of the ovisac, already

I had also observed and sketched, as seen both in the Fallopian tube and at its fimbriated extremity, traces of what was probably a corresponding membrane, though perhaps in an incipient state (Plate II., fig. 48, γ) ; in one instance along with young and blood-red epithelium cells. The latter when fully formed, I had also seen and figured (Plate II., fig. 54, ζ) "adhering by their distal extremities," in the manner described by Goodsir; as well as what appear to have been cytoblasts and cells of a germinal membrane, for forming epithelia, fig. 54, α, β, γ, δ. And I would offer the diagram, fig. 53, in Plate II., as the probable mode of origin and evolution of the epithelium cells.

This diagram represents a germinal membrane, *resting on capillaries such as those in fig.* 48, β, *Plate II.;* having on the extreme left a cytoblast, marked IV., in the state represented by the woodcut, fig. 4. The cytoblast becomes a cell, marked V., which is in the state of that in the woodcut, fig. 5. VI. In the diagram corresponds to the woodcut, fig. 6; and so on, as far as XI.; after which the epithelium cells are given off, adhering to the membrane of the cell or cells in which they arose; and leaving the nuclei, which are in outline only, in a state for producing another brood.

This explanation, rendering it needless to suppose that there occurs a splitting of the germinal membrane into two layers, seems to meet a difficulty spoken of by Goodsir; and it probably applies as much to the supposed splitting of what has been called the "germinal membrane" in the ovum; for in both there is formed a "mucous" or epithelial surface.

But if the diagram in question explains the mode of origin of epithelium cells, it may also admit of a further and a more important application. *I found the red colouring matter of*

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mentioned in pp. 207 and 209 of this paper, and to accord with my belief in the compound structure of the membrane of every cell. With regard to the question at present much occupying the attention of Vegetable Physiologists—Whether, in the thickening of the cell-membrane, the inner or the outer layer s the last formed,—all my observations on the functions of the nucleus are of course in favour of the *inner* layer being formed last (see fig. 40.) But if the primitive membrane of the cell be, as I believe, a compound structure, it has in its own substance the means of contributing towards its thickening. (See Phil. Trans., 1841, Plate XXV., figs. 170–173.)

the blood to reappear in the epithelium cells. And I am incapable of understanding the presence in large quantity, in the Fallopian tube, of red blood-discs and cells such as those at θ in the figure, without supposing that they have here, as well as elsewhere, their origin in parent-cells, such as the epithelium cells at η seem to have been. Now, out of blood-red discs (fig. 54, θ), as I long since shewed, are formed cells with processes or arms (ι), and out of these is formed the chorion ($\varkappa$); which, by the remarks now made, I am endeavouring to connect with the blood-corpuscles in the circulation,—for, it will be recollected, the epithelium cells derive their origin from capillaries such as those in fig. 48, β, *containing only blood-corpuscles, and no liquor sanguinis at all.*

And if it be thus possible to trace the elements of the chorion from a free surface, through epithelium cells, to the blood-corpuscles, how much more is it not possible to refer to those corpuscles the elements of the tissues, as well as all nutrition; seeing that here we have a more direct communication, and no epithelium cells?

Having, six years since, investigated the mode of origin of nearly every tissue of the body, and written a long memoir for the sole purpose of communicating the results of those investigations,* I need not here refer to the subject in any other, than a very general manner. In that memoir I stated the tissues to be formed of "corpuscles, having the same appearance as corpuscles of the blood," and did not hesitate to add my belief that the corpuscles having that appearance, and entering into the formation of the tissues, were derived from blood-corpuscles which had been in the circulation. My views are stated somewhat in detail, in the description of figs. 47 and 48 of Plate II.; to which description I refer, and would here simply add, that there was no liquor sanguinis in the capillaries represented in those figures; that I believe it to be the hyaline from the centres of blood-corpuscles that escapes from the capillaries for nutrition and the formation of new parts,—globules of which hyaline become red cytoblasts, exactly like those still in the circulation; and that,

* "On the Corpuscles of the Blood," Part III., Phil. Trans. 1841.

centres being observable in the walls of capillaries (Plate II., fig. 49 δ,) which are evidently nuclei of the cells forming those capillaries, it is probable that *the walls of capillaries also are germinal membranes*, which, by their nucleal orifices, take up and distribute on their exterior the hyaline of the blood-corpuscles; this hyaline being then absorbed by other centres for nutrition or the formation of new parts.

Explanation of the Plates.

PLATE I.

Fig. 33. From ova of the Rabbit. α, Network representing part of the incipient umbilical vesicle. A hollow process or little sac, consisting of incipient cells, having been given off by the rudimental embryo (the nucleus of a cell), those cells coalesce where in contact, and form this network; which, enlarging, at length lines the ovum. The pellucid nuclei of the coalesced cells are at the surface of their cells. They are surrounded by minute globules, and *have no nucleolus.* β, The same object in a stage more advanced. It now lines the ovum, and the membranous portion of the network is disappearing. *A nucleolus is now coming into view.* γ, Stage still more advanced;—all traces of a network have disappeared, and the nuclei alone remain.—(Phil. Trans., 1839. Plates VIII. and VII., Figs. 132, 120, 121.)

Fig. 34. A later stage of the objects in the preceding figure. Cells have been formed by cytoblasts, arising out of bodies such as those in fig. 33, γ. Each cell has a pellucid nucleus, corresponding to that which was the nucleolus in fig. 33, γ. And *what were nucleoli in fig.* 33, γ, *are now nuclei.* Of these nuclei, there are seen in the figure three stages, α, β, γ,—α exhibiting the least advanced, and γ the most forward stage. α, The nucleus is merely a portion of hyaline, not surrounded by any globules, *and not having a nucleolus.* β, Globules are now seen surrounding the nucleus, and in two instances a nucleolus is coming into view. γ, The nucleus is now surrounded by a membrane, formed by globules such as those at β, and it *has now a well-defined nucleolus.*—(Phil. Trans., 1839, Plate VIII., fig. 150.)

Fig. 35. Young blood-corpuscles of the tadpole of the large Toad of Jersey. They are cytoblasts.—(Phil. Trans., 1841, Plate XX., fig. 74, β.)

Fig. 36. Young blood-corpuscles, α of the Leech, and β of the fœtal Sheep. Some of the latter are escaping from the parent-cell.—(Phil. Trans., 1841, Plates XIX. and XXIII.)

Fig. 37. Blood-red bodies derived from blood-corpuscles of a bird, the Wryneck (*Yunx Torquilla*, LINN.); and forming ova in their ovisacs. α, Originally elliptical, has become round. β, The outer part consists of cytoblasts, which surround a central cytoblast. γ, The central cytoblast has become a cell, the germinal vesicle, and exhibits a distinct orifice in the situation of the future germinal spot. (The entire body γ appeared to be membranous at its surface, from the remains of the cell-membrane formed by its cytoblast.) δ, The germinal vesicle and its orifice are much larger. ϵ, The germinal vesicle has fur-

ther increased in size, and the peripheral cytoblasts are dividing into minuter cytoblasts, *i. e.*, they have formed cells which exhibit (are being reproduced by) a cell-formation in their interior. (Phil. Trans. 1841, Plate XXV., figs. 165–167.)

Fig. 38. From the same ovary. Portion of the membrane of an ovisac, which was elliptical, and $\frac{1}{3}'''$ in length as it lay crushed under glass. It still presented a pale tinge of red, as well as a trace of the minute cells of which the membrane is composed. (Phil. Trans., 1841, Plate XXV., fig. 172.)

Fig. 39. Blood-corpuscles, and cells &c. derived from blood-corpuscles, of the Lobster, Tadpole, Cod, Chick *in ovo*, Rabbit, and fœtal Sheep and Ox. All drawn on the same scale; magnified 600 diameters. (Phil. Trans., 1840 and 1841.) Most of the larger of these bodies are very much in outline.

Fig. 40. The germinal vesicle, and some of the surrounding substance, in an ovum of the Tiger, after the ovary had been for a short time macerated. The germinal vesicle had become elliptical, and out of the germinal spot there had arisen three concentric cells. (Phil. Trans., 1839, Plate V., fig. 89). See the description of fig. 41.

Fig. 41. A nucleus in its cell. The nucleus consists of two concentric cytoblasts, the inner being the one last formed. The nucleus of this cell was the rudimental embryo of the Rabbit. (Phil. Trans., 1839, Plate VIII., fig. 148.)

Fig. 42. The nucleus of one of the twin cells in an ovum of the Rabbit of 17 hours, from the Fallopian tube. Its external part consisted almost entirely of cytoblasts. (Phil. Trans., 1840, Plate XXIV., fig. 192.)

Fig. 43. Nucleus of one of the transitory cells in an ovum of the Rabbit from the Fallopian tube, of the same age as that in the preceding figure. (Phil. Trans., 1840, Plate XXIV., fig. 189.)

Fig. 44. After Harless. α, β, γ, Cells of ganglion-globules in the lobus electricus of the Torpedo Galvanii; shewing a connection between nervous filaments, and what Dr Harless terms the nucleus of an inner cell. See pp. 217, 218 of this Journal.

Fig. 45. α, An ovarian ovum of a rabbit killed in the state of heat; in diameter $\frac{1}{11}'''$. *c*, Germinal vesicle. β, The pellucid centre of the altered germinal spot on a larger scale, from an ovum of the same ovary as the ovum α. (Phil. Trans. 1840, Plate XXII., Fig. 162.) Compare with Fig. 46.

Fig. 46. After H. D. S. Goodsir. Ovules of Cænurus cerebralis. α, "Fifth stage of ovule. C, primary germinal vesicle; D, primary circle of cells; E, central cell of primary circle of cells become larger; F, its nucleus, become larger and nodulated." β, "Ovule of Cænurus, very far advanced in the discoidal period of developement. The concentric circlets of cells are seen; and the central circlet near to the lower edge as it was pressed between the plates of glass, shewing that there is elevation, to a certain extent, during the latter stages of this period. A, external covering of gemmule; C, some of the concentric circles of young cells; C, central cell of last formed circlet; D, its nucleus and clear space." (Trans. R. S. E., 1844, Vol. XV., Plate XVI., Figs. 5 and 9.)

PLATE II.

Fig. 46½. Blood-corpuscles from the edge, posterior surface, and neighbour-

hood of the crystalline lens in the chick *in ovo* and a fœtal sheep; very much enlarged, especially the hyaline, which has increased in quantity at the expense of the red colouring matter. Magnified 600 diameters. (Phil. Trans., 1841.) See the description of Fig. 47.

Fig. 47. A small portion of one of the dilated capillaries at the edge of the crystalline lens in a fœtal ox of 18 inches; filled with blood-corpuscles in greatly enlarged and altered states. This capillary was most unequal in calibre at different parts. Magnified 600 diameters. (Phil. Trans., 1841, Plate XXIV., Fig. 152.) The blood-corpuscles, or rather cells, were for the most part ruptured. At the upper part of the figure on the right hand, they were still entire. The part reddened is the red colouring matter, and the white exhibits the hyaline from the ruptured cells. In the capillaries the red colouring matter of the corpuscles serves as a sort of pabulum for the hyaline centres of those corpuscles; the quantity of which hyaline in some corpuscles becomes, as in the present instance, where new parts were forming, prodigiously large; the red colouring matter in proportion disappearing. This capillary *contained no liquor sanguinis.* The hyaline, from the nuclei of the blood-cells, is the substance which seems to pass through the walls of the capillaries; and in some parts (α) there are seen what appear to be nucleal orifices for this purpose. (See also δ of Fig. 49.)

Globules of the hyaline, after escaping from the capillaries, seem to become cytoblasts, in which red colouring matter is again formed; not excepting even those entering into the formation of the pellucid crystalline. Several of the bodies last referred to are seen in outline at β. (This originally colourless substance, derived from the nuclei of blood-cells, appears to constitute the essential part of coagulable lymph, to organise the same, to serve for nutrition, and to give origin to the tissues, &c. It seems to be this same originally colourless substance, derived from the nuclei of blood-cells, that forms the exudation-corpuscles of authors, the filaments of false membrane, and the filaments in coagulating blood; filaments which, as I have shewn, here and there arise while this substance is still within the cells.)

Fig. 48. α, Outline of capillaries as seen at the inner surface of the wall of the infundibulum of the Fallopian tube, in a rabbit killed $5\frac{1}{2}$ hours *post coïtum.* At the lower part are epithelium cells carrying cilia. These epithelium cells are arranged parallel to one another, and perpendicular to the general direction of the capillaries. The small extremity of the epithelium cells is directed towards the capillaries: whence their frill-like appearance (in the figure), and the great extent of their ciliary surface. External diameter of the largest vessel $\frac{1}{200}$.''' 100 Diam. β, A portion of the capillary plexus α, magnified 300 diameters. These capillaries are in the state of vital turgescence; *filled* with blood-corpuscles (which have become true cells), *to the exclusion of surrounding fluid.* Such is the state of all the capillaries in that region at such time. Many of the corpuscles so minute that their hyaline presented the appearance of a dark point. γ, Network formed by the coalescence of cells derived from corpuscles of the blood; which, like those entering into the formation of the chorion, have for this purpose sent out processes or arms. The finest ramifications in arborescent states of the capillaries, like that at α, have sometimes appeared to pass into a network of this kind.

Fig. 49. Capillaries in the course of formation by cells derived from corpuscles of the blood, in the retina of a fœtal ox of 18 inches. These cells, while still red (α), apply themselves together, so as to form a necklace-like object, composed of elliptical beads; and having coalesced, and become pale (β), and the membranous partitions having disappeared, they form a tube. Magnified 600 diameters.—(Phil. Trans. 1841, Plate XXII., fig. 107). Nucleal centres or orifices, forming communications apparently between the interior and exterior of these vessels, are seen at δ in two parts.

Fig. 50, after Professor Goodsir (Anatomical and Pathological Observations, 1845, Plate I., fig. 11). "Diagram of mucous membrane of jejunum when absorption is not going on. *a*, Protective epithelium of a villus, *b* secreting epithelium of a follicle, *c c c* primary membrane, with its germinal spots or nuclei *d d*. *e*, Germs of absorbent vessels. *f*, Vessels and lacteals of villus."

Fig. 51. From the Ox. Granules of the ovisac with their nucleus. In one instance a single granule presents two nuclei. This granule measured $\frac{1}{150}$th Paris line in length.—(Phil. Trans., 1838, Plate VIII., fig. 73.) These granules are cytoblasts; exceedingly well seen in the ovisac: which contains little of any thing besides, in a solid form.—(See the four Plates, V., VI., VII., VIII., in the Phil. Trans, above referred to.)

Fig. 52. Part of the ovum of the Common Leech, drawn by Professor E. H. Weber, of Leipzig (Ueber die Entwickelung des medicinischen Blutegels, in Meckel's Archiv, 1828, Taf. X., fig. 7). See page 222 of this Journal.

Fig. 53. Diagram to shew the probable mode of origin of epithelium cells. (See p. 224).

Fig. 54. From the Fallopian tube of the Rabbit. α, β, γ, δ, Bodies which seem to have been the nuclei, cytoblasts, or cells, from a germinal membrane such as that in the diagram, fig. 53. (Compare δ in this figure with X. in fig. 53). ε, Young epithelium cells. (Compare with XI. in fig. 53). ζ, Fully formed epithelium cells, with their cilia. η, Cells filled with cytoblasts. They seem to represent parent-cells, giving origin to such bodies as those at θ, which are obviously derived from corpuscles of the blood. ι, Some of the latter (θ), now become cells with processes or arms; which, interlacing, enter into the formation of $\varkappa$, the incipient chorion.—(Phil. Trans., 1840, Plates XXVIII., XXIX.)

PLATE I.

Mammiferous Ovum.
(M. Barry, 1840.)

Ova of a Cystic Entozoon.
(H.D.S. Goodsir, 1844.)

PLATE II.